Coastal Variability Analysis, Measurement, And Prediction (COVAMP)

Richard A. Paulus
SPAWARSYSCEN San Diego D858
49170 Propagation Path
San Diego, CA 92152-7385
phone (619) 553-1424 fax (619) 553-1417 email paulus@spawar.navy.mil

Document Number: N0001401WX20193
http://sunspot.spawar.navy.mil/543

LONG TERM GOALS

The long-term goal is to provide representative three-dimensional, time-varying refractivity and optical property inputs for propagation models.

OBJECTIVES

The objectives are to provide a testbed to develop and evaluate urgently needed state-of-the-art measurement capabilities and accurate now- and forecasting techniques. EOPACE was a five-year multinational and interdisciplinary effort to improve the performance assessment for electrooptical (EO) systems operating in coastal environments.

APPROACH

No one instrument or model is currently available with the capability to characterize propagation conditions on the necessary spatial and temporal scales thought to be typical of the coastal regions. Therefore, sensing information from a variety of sources/instruments are to be combined with high-resolution meteorological mesoscale models to provide a better description of the propagation environment than either sensing or models alone. COVAMP is divided into 2 tasks: (1) Electrooptical Propagation Assessment in Coastal Environments (EOPACE) and (2) Sensing of Atmospheric Refractivity (SOAR).

The EOPACE measurement effort completed in FY99; analysis and publication of data conducted in FY00-01. Dr. Doug Jensen was the PI for EOPACE with collaborators in D858 SSC San Diego (Stu Gathman, Charlie McGrath, and Dr. Carl Zeisse), FEL/TNO (G. De Leeuw, A. de Jong), DREV (D. Dion, L. Forand), University of Manchester (M. Smith), and Naval Postgraduate School (K. Davidson, P. Frederickson). The EOPACE task was completed in FY01.

The SOAR task is to perform the experimental work that will improve and validate the models and techniques for sensing atmospheric refractivity and the data fusion methods for combing the outputs. Rich Paulus is the PI for SOAR. The SOAR task was cancelled in FY01 for lack of funding.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2001**	2. REPORT TYPE	3. DATES COVERED **00-00-2001 to 00-00-2001**

4. TITLE AND SUBTITLE **Coastal Variability Analysis, Measurement, And Prediction (COVAMP)**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **SPAWARSYSCEN San Diego D858,,49170 Propagation Path,,San Diego,,CA, 92152**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The long-term goal is to provide representative three-dimensional, time-varying refractivity and optical property inputs for propagation models.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

WORK COMPLETED

EOPACE

The EOPACE measurement and analysis campaign consisted of nine intensive operational periods (IOPs) conducted on the western and eastern coastal regions of the United States (California and North Carolina, respectively) since January 1996. The objective was to determine the impact of coastal aerosols on electrooptical propagation in a coastal environment. The completed EOPACE database, IOPs 1-9, has been compiled and distributed to all participants on CD. Our final paper on EOPACE was published in *Optical Engineering* [Jensen *et al*., 2001].

SENSING OF ATMOSPHERIC REFRACTIVITY

FY01 is the third and final year of SOAR. We completed a numerical study of subrefractive conditions in the marine atmospheric surface layer. The results were documented in an SSC technical report and presented at the National Radio Science Meeting in January 2001.

We completed an analysis of evaporation duct and subrefractive layer height correlation using historical data from a NOAA data buoy at Tanner Banks, the 2 ONR-SIO Marine Observatory buoys, and a meteorological buoy deployed for the NATO RSG-8 experiment near Lorient, FR in 1989. The results were presented at BACIMO 2001 and published in the proceedings.

We began an analysis of the radio-meteorological data from the NATO RSG-8 experiment near Lorient, FR in 1989 comparing observed with propagation model predicted propagation loss. The meteorological conditions during this experiment were such that the surface layer was stable approximately 72% of the time during which evaporation ducting prevailed 63% of the time and subrefraction prevailed 37% of the time. Initial results are being submitted for presentation at the National Radio Science Meeting in January 2001.

We have been operating the PMW 155 Supplemental Weather Radar (AN/FPS-131) at Point Loma to gather sea and land clutter data under varying propagation conditions. Radiosonde observations were made at time of special interest. These data support the Refractivity from Clutter work.

RESULTS

EOPACE

EOPACE results have been summarized in previous year end reports and in *Jensen* [2001].

SENSING OF ATMOSPHERIC REFRACTIVITY

Paulus [2000, 2001] demonstrated that subrefractive conditions in the marine atmospheric surface layer can be parameterized, in a manner similar to the evaporation duct, by a characteristic height that is physically the height of the maximum of the refractivity profile as derived from a surface layer model based on Monin-Obukhov similarity theory. Analysis of the temporal and spatial variation of evaporation duct and subrefractive layer height [*Paulus and Moision*, 2001] showed the expected greater variability of layer heights in the littorals versus open ocean but also showed the temporal variation of layer heights in the littoral to be greater.

IMPACT/APPLICATIONS

The spatial and temporal data collected under this project are used to validate system performance models and provide variability statistics to EM/EO system designers. The EOPACE effort has resulted in quantifying the effects of aerosols in the variable coastal regime and, in particular, the effects of surf-generated aerosol on IR transmission within this coastal environment. EOPACE results are impacted the scientific community through EOPACE sessions in the NATO Sensors and Electronics Technology Panel Symposia, SPIE Symposia on "Propagation and Imaging Through the Atmosphere," the European Aerosol Conference, invited papers at the LASE 2000 SPIE and URSI General Assembly '99 Symposia, and presentation at technical symposium such as AGARD, the Battlespace Atmospheric Conferences, IGARSS, IRIS, and organizational technical reports.

The development of a parameterization for surface layer subrefractive conditions provides the potential to compile statistics for subrefraction in the same manner as the evaporation duct climatology currently in the Oceanographic and Atmospheric Master Library. Such a parameterization also impacts the development of Refractivity from Clutter in providing an efficient means to characterize subrefraction. The temporal and spatial variability of the evaporation duct and subrefractive layers impacts the design of meteorological sensor systems in determining how often the environment should be measured and impacts the operation of EM systems in determining how long the current refractive conditions will persist. For example, Figure 1 is the results of the lag analysis for the meteorological data collected during the NATO RSG-8 experiment September to November 1989 off Lorient.

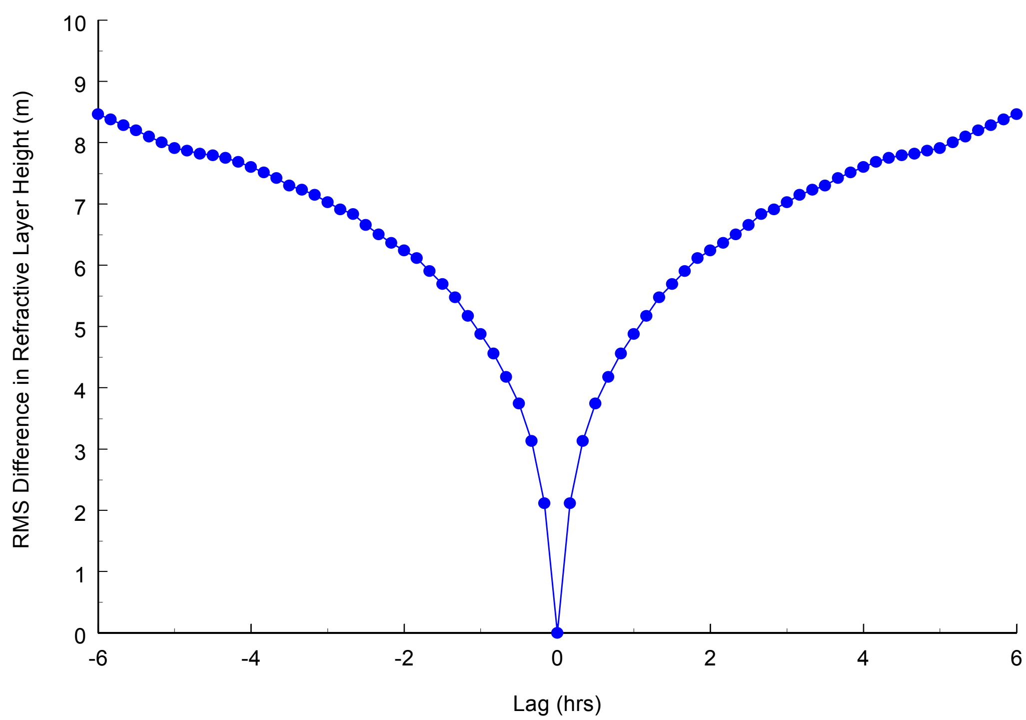

Figure 1. RMS difference in refractive layer height vs. lag time. Refractive layer height includes characterizations of both evaporation ducting and subrefraction.

TRANSITIONS

EOPACE field experiments have provided a rich database for analysis of propagation effects, subsequent model development, and validation.

RELATED PROJECTS

This project is closely related to the synoptic and mesoscale numerical analysis and prediction projects pursued by NRL Monterey, the EM Propagation and EO Propagation projects, and the Remote Refractivity Sensing project under ONR 321SI.

SUMMARY

The initial results of the EOPACE program include: (1) the parameterization of the surf-zone generated aerosol-size distribution as a function of swell height; (2) the characterization of aerosol plume structures and the transport of surf generated aerosols; (3) the development of a quantitative surf aerosol source function; (4) the description of the contribution and impact of surf-zone generated aerosols on coastal infrared (IR) transmission; (5) the measurement and modeling of the near surface transmission effects (aerosol and molecular extinction, refraction, scintillation, and wave shadowing); (6) an analysis of the contribution of anthropogenic and land derived aerosols to the air mass characteristics in the coastal zone; (7) the application of direct and remote sensing techniques to develop the scaling parameters for aerosols in the prevailing air mass; (8) an analysis of near ocean surface bulk meteorological scaling which works well for unstable conditions but is less reliable for neutral and stable conditions; and (9) the incorporation of the improved sea radiance models into TAWS (target acquisition weather software) which improved the error analysis by a factor of 3.

The SOAR effort has (1) developed a parameterization for marine atmospheric surface layer subrefractive conditions, (2) quantified temporal and spatial variability of evaporation duct and subrefractive layer heights in representative open ocean and littoral waters.

PUBLICATIONS

EOPACE

Jensen, D.R., S.G. Gathman, C.R. Zeisse, C.P. McGrath, G. de Leeuw, M.H. Smith, P.A. Frederickson, and K.L. Davidson, "Electro-optical propagation assessment in coastal environments (EOPACE): summary and accomplishments," *Optical Engineering, 40*(8), pp1486-1498, 2001.

SENSING OF ATMOSPHERIC REFRACTIVITY

Paulus, R.A. and K.D. Anderson, "Propagation Modeling In A Stable Marine Atmospheric Surface Layer," abstract submitted for the National Radio Science Meeting, Boulder, CO, 9-12 January 2002.

Paulus, R.A. and W.K. Moision, "Analysis of Evaporation Duct Height Correlation," Proceedings of the Battlespace Atmospheric and Cloud Impact on Military Operations Conference, BACIMO 2001, Fort Collins, CO, 10-12 July 2001.

Paulus, R.A. "Simulation of Evaporation Duct and Anti-Duct Propagation Effects," National Radio Science Meeting, Boulder, CO, 8-11 January 2001.

Paulus, R.A., "Parametric Study of Propagation in Evaporation Ducting and Subrefractive Conditions," TR 1844, SSC San Diego, November 2000.